Fluid composition and pressure history studies in chalk, Skjold Field, Danish North Sea

Peter Scholle
New Mexico Bureau of Geology and Mineral Resources, Socorro, New Mexico

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Because North Sea chalks are extremely fine grained and have low permeabilities, they typically require 25% or more porosity to be productive hydrocarbon reservoirs. Preservation of such substantial porosity in deeply buried chalks requires unusual conditions because chalks lose pore space rapidly as a result of chemical and physical compaction associated with overburden loading.

Overpressuring is particularly widespread in North Sea chalks as a consequence of rapid rates of sediment accumulation and low permeability of both the chalks and the overlying Tertiary section. Studies indicate that the overpressuring currently seen in many areas has existed for at least 10 million years, in some areas possibly in excess of 30-35 million years. Maintenance of substantial overpressures for such long periods of time is difficult, particularly in areas of substantial tectonic activity (e.g., along faults or on piercement salt domes). Partial or complete loss of overpressures at any stage after their initiation could lead to rapid porosity loss until overpressures were reestablished. Thus, understanding the history of regional and local pore-fluid pressure variations is an important factor in models used to predict porosity variations in chalks of the North Sea Basin.

Geochemical studies, especially fluid-inclusion investigations, of Cretaceous chalks of the Skjold Field in the Danish North Sea have provided insights on episodic variations in fluid compositions, and thus, by inference, into variations in fluid throughput and pore pressure history of that field. Successive generations of calcite cements in fractures from chalks on this salt dome structure show alternations between zones of water- and oil-filled fluid inclusions, sometimes with a corrosion zone between them. Those variations are interpreted to reflect at least two episodes of oil filling and overpressuring of the structure, followed by failure of the seal, with loss of overpressuring and oil charge. Following those pressure dissipation events, calcite cementation under aqueous conditions helped to heal the extensive fractures produced in the chalk. This allowed gradual repressurization and refilling of the structure with hydrocarbons.

Other lines of evidence that support the concept of repeated pressurization-depressurization and the movement of deep basin waters through the field include the presence of oil trapped in low porosity and permeability chalks, extensive alteration of carbon and oxygen isotopic ratios, anomalously high fluid inclusion temperatures, significant dolomite in some horizons, and the presence of celestite in fracture fills

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